Reconnection Outflows in the Extended Corona and Magnetotail

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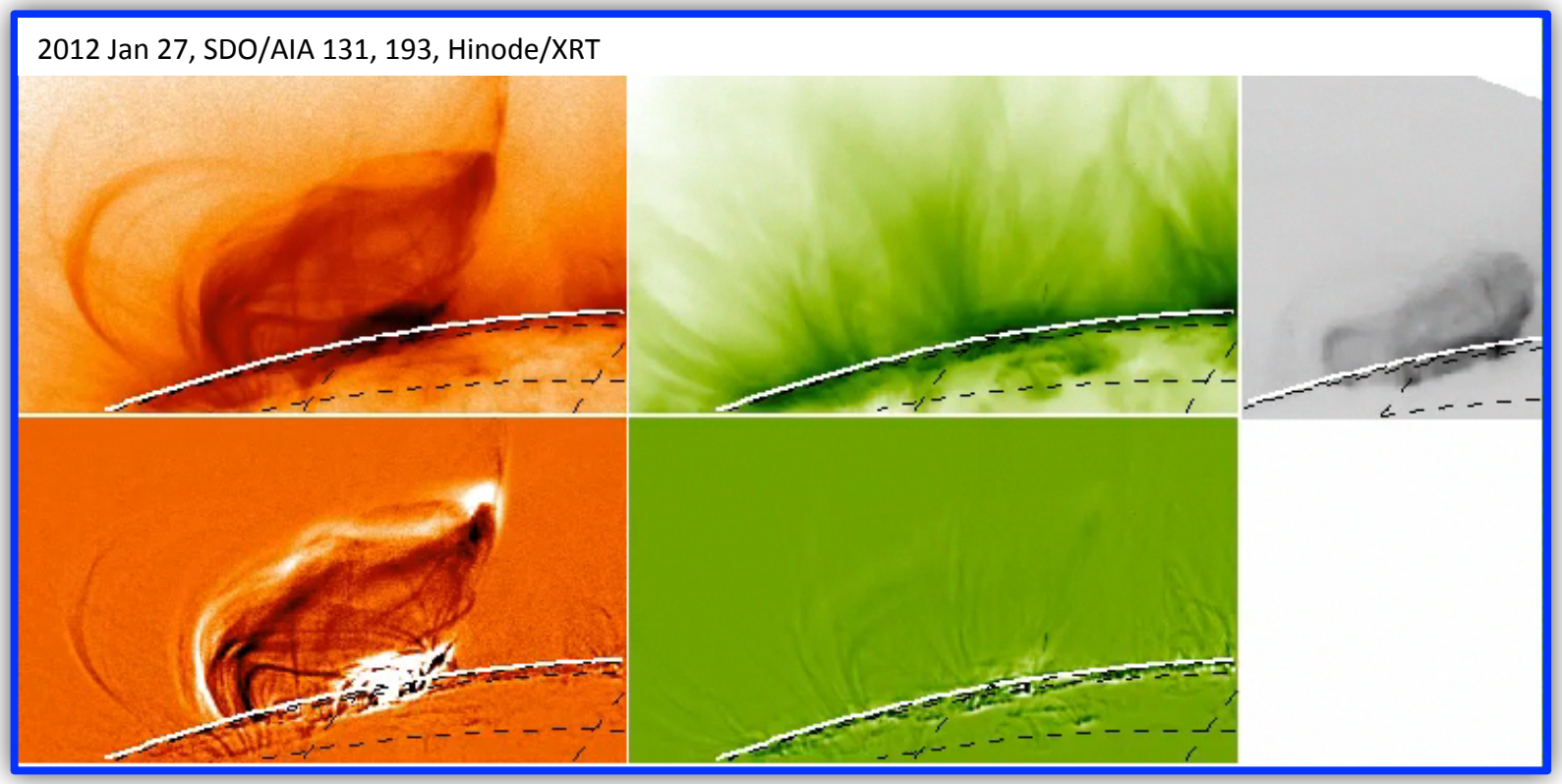
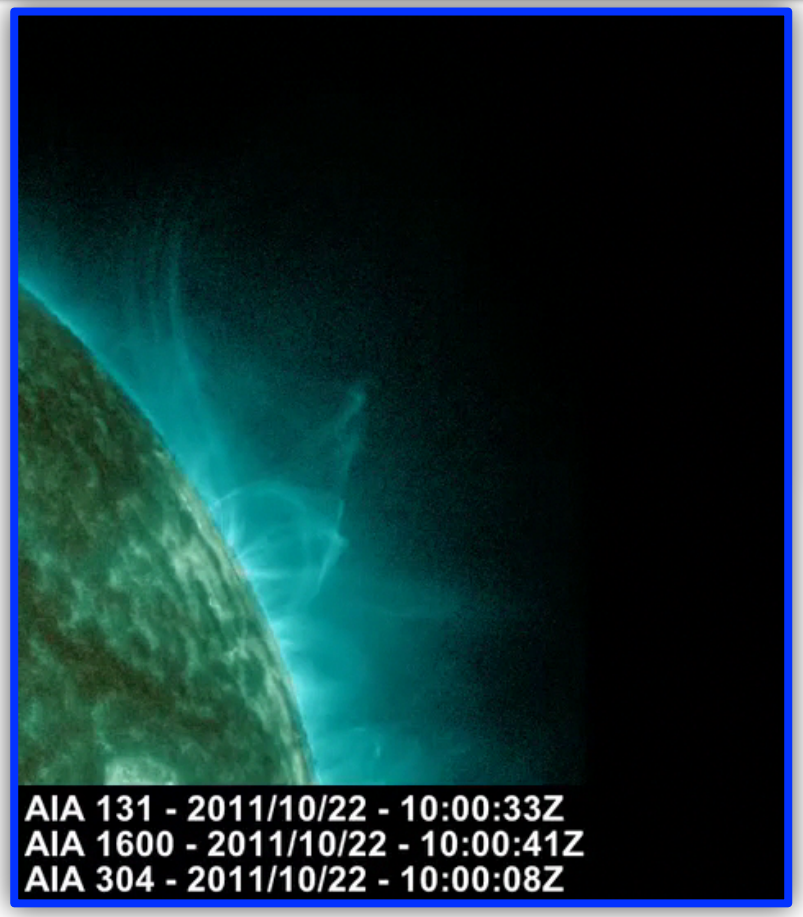
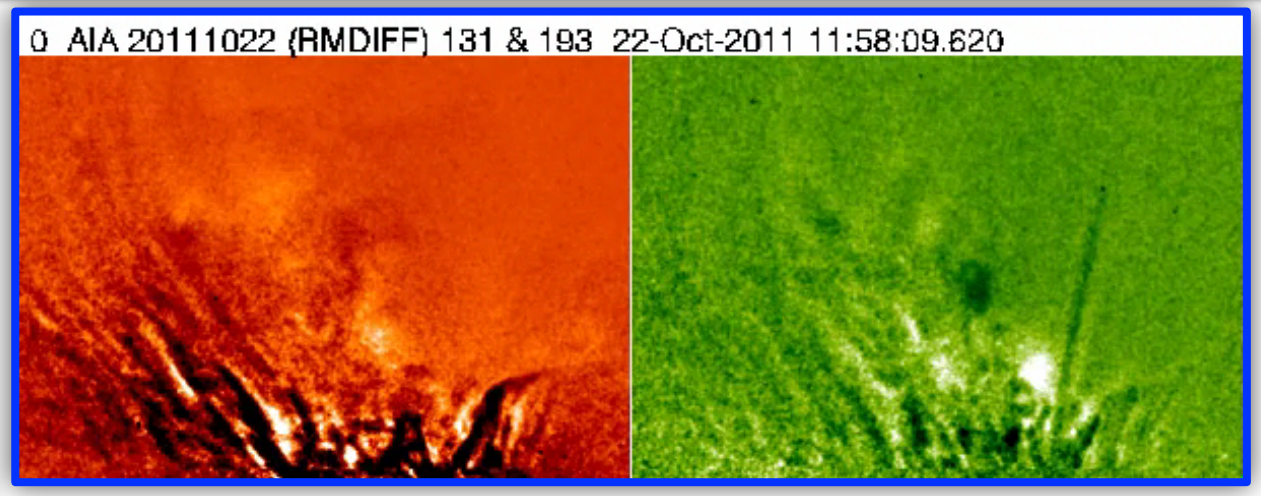
*Considerable contributions from K. Reeves & D. McKenzie

Supra-Arcade Downflows (SADs) and Downflowing Loops (SADLs) Observations



SADs + SADLs

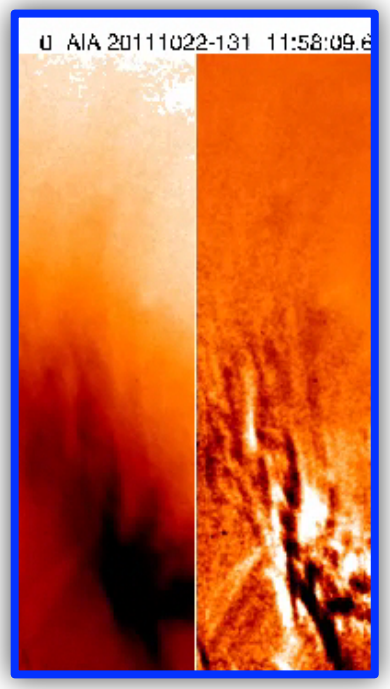




Hot AIA channels. (2-10 MK)

Run-mean-differenced

Reverse-scaled



Courtesy D. McKenzie

Savage et al. 2012

SADs + SADLs

- Key features
  - Different from plasmoids
  - Observationally associated with inflows (as outflows)
  - Significant correlations with particle acceleration and heating (temporally and spatially), thanks to RHESSI and radio observations

Diagram Models

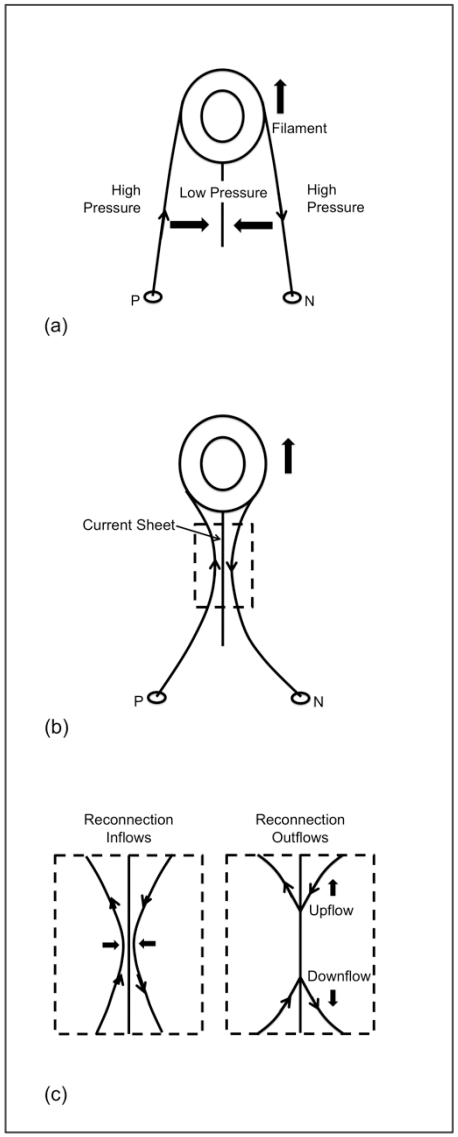
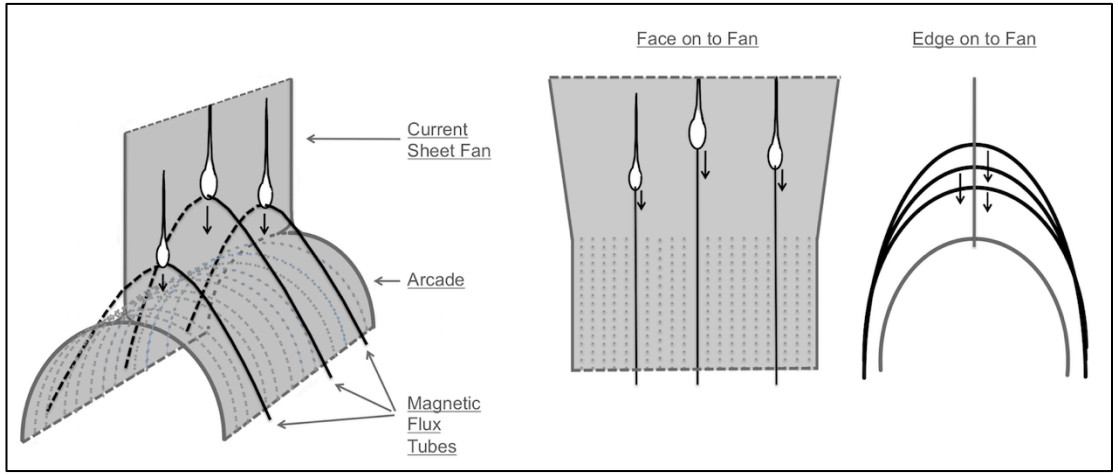
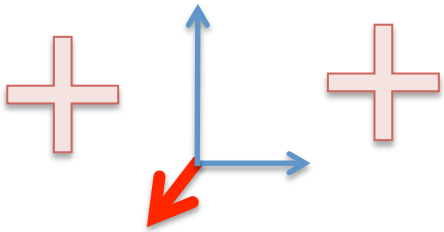


Fig 1

Fig 2





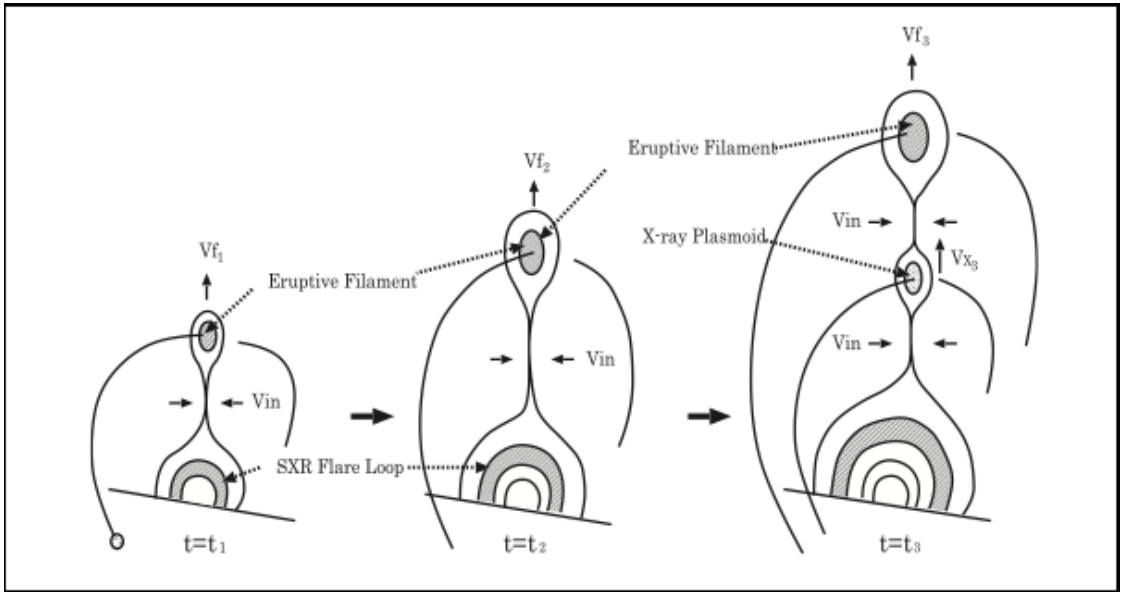
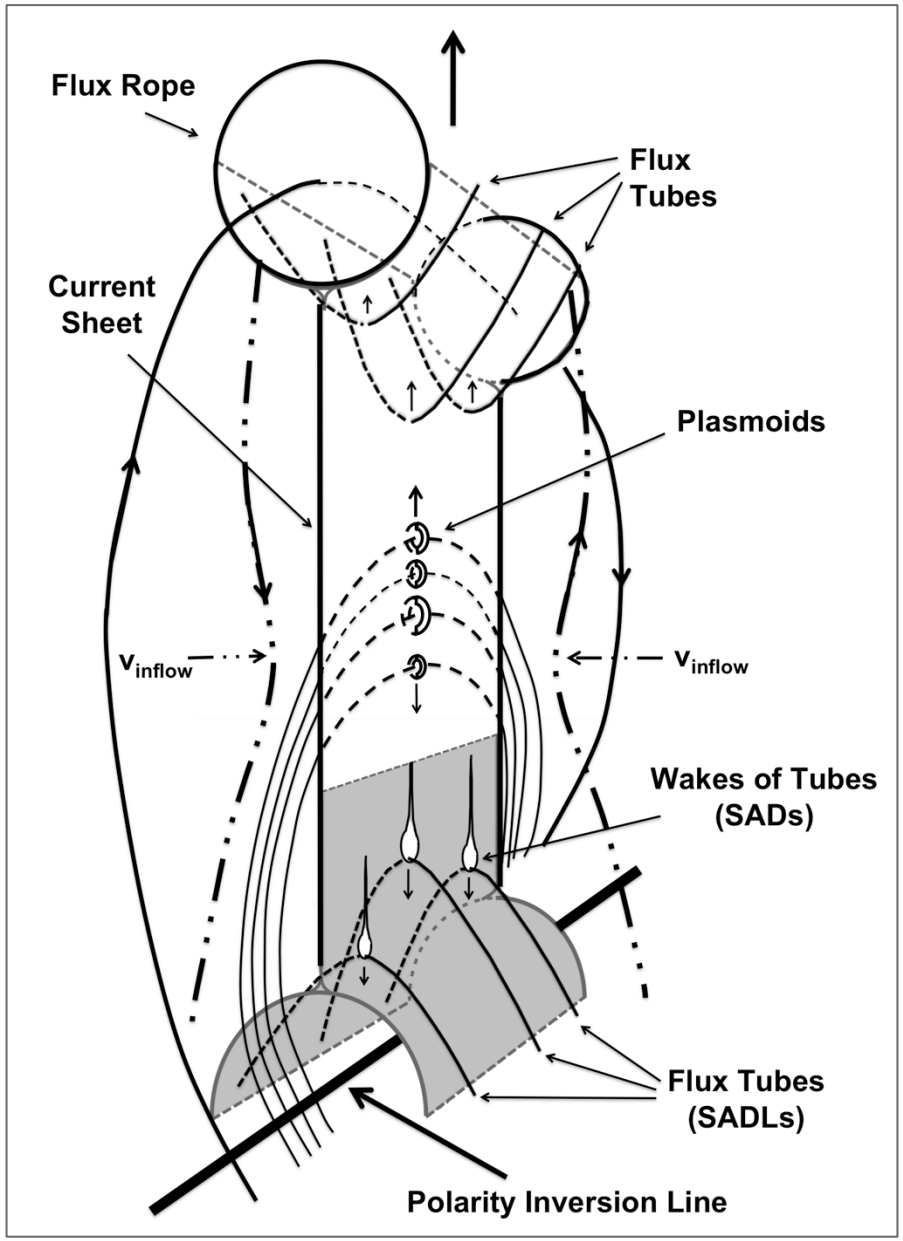


Fig 3

Fig 1, 2: Savage et al. 2012

Fig 3: Ohyama & Shibata 2008

Fig 1



Basic reconnection scenario, post initial flux rope formation and release.

- Field lines reconnect across the current sheet to form outflowing flux tubes while plasmoids form along the current sheet.
- SADs are formed as the flux tubes (SADLs) retract through hot plasma in the fan (*otherwise, only SADLs are observed*).

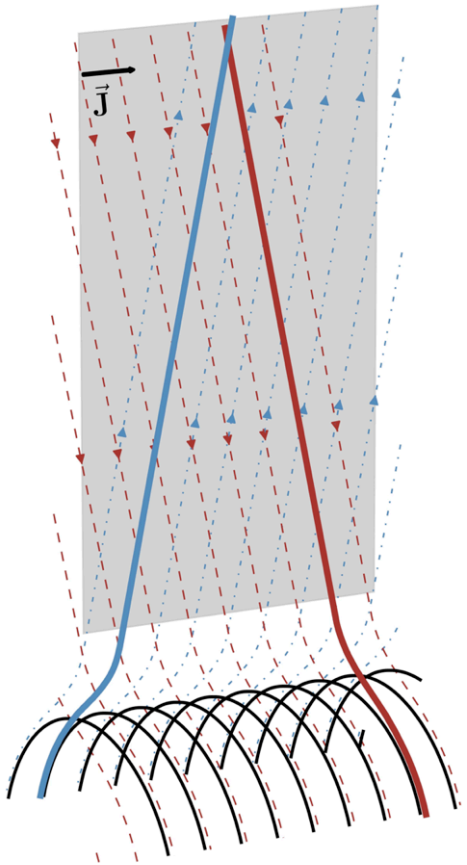


Fig 1: Savage et al. 2012

Fig 2: A. Kobelski

SADs in the Extended Corona

Fig 1

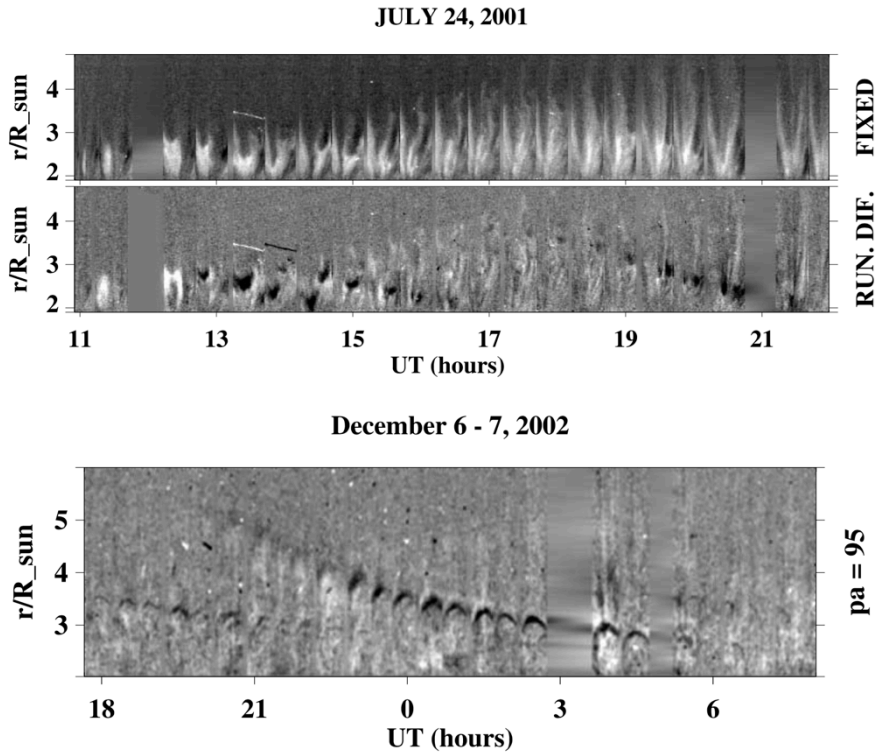
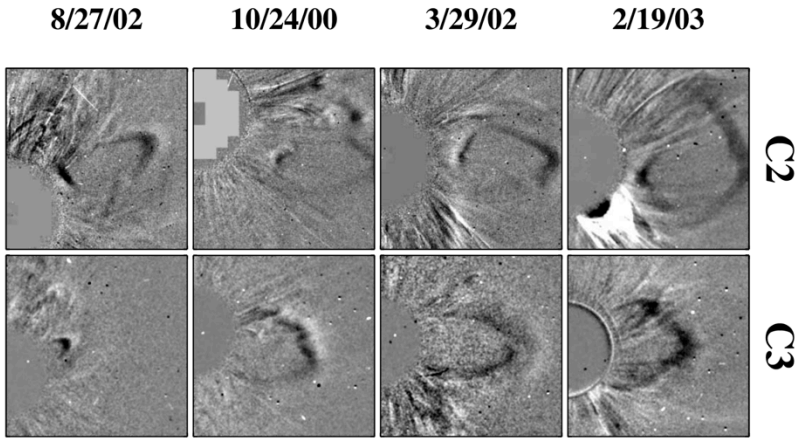
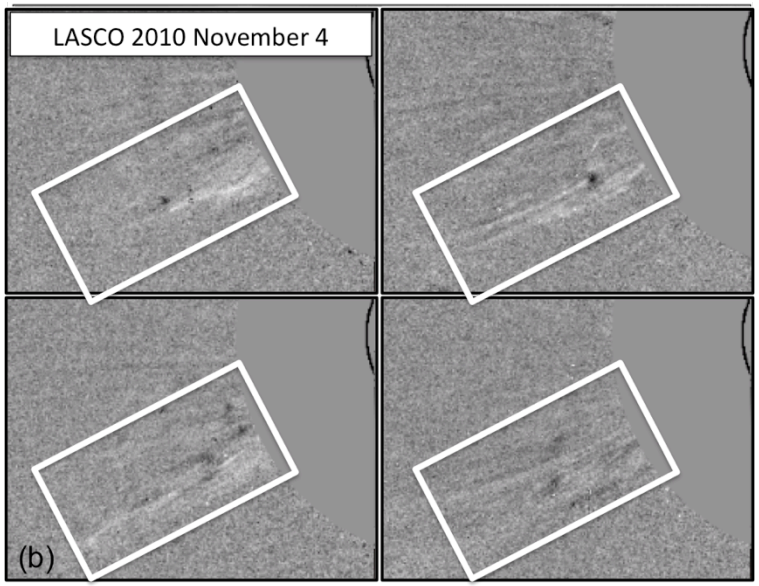


Fig 2





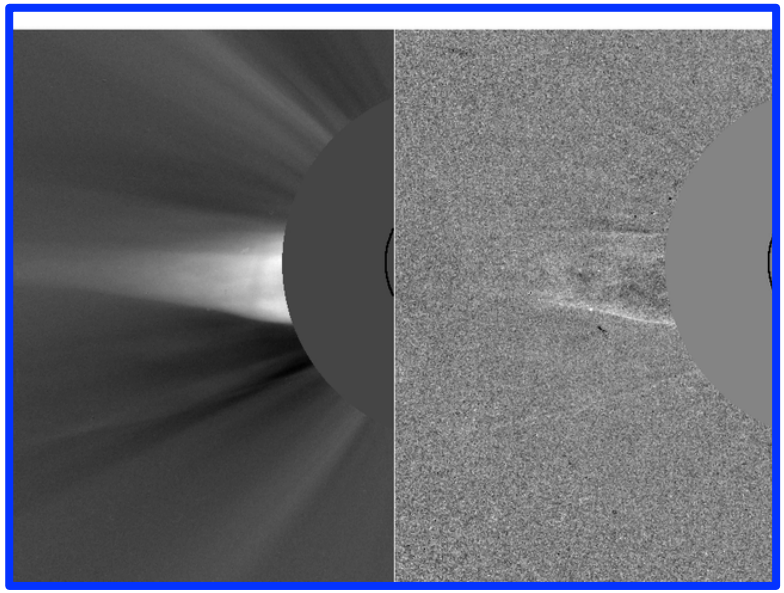


Fig 1: Sheeley, Warren, & Wang 2007

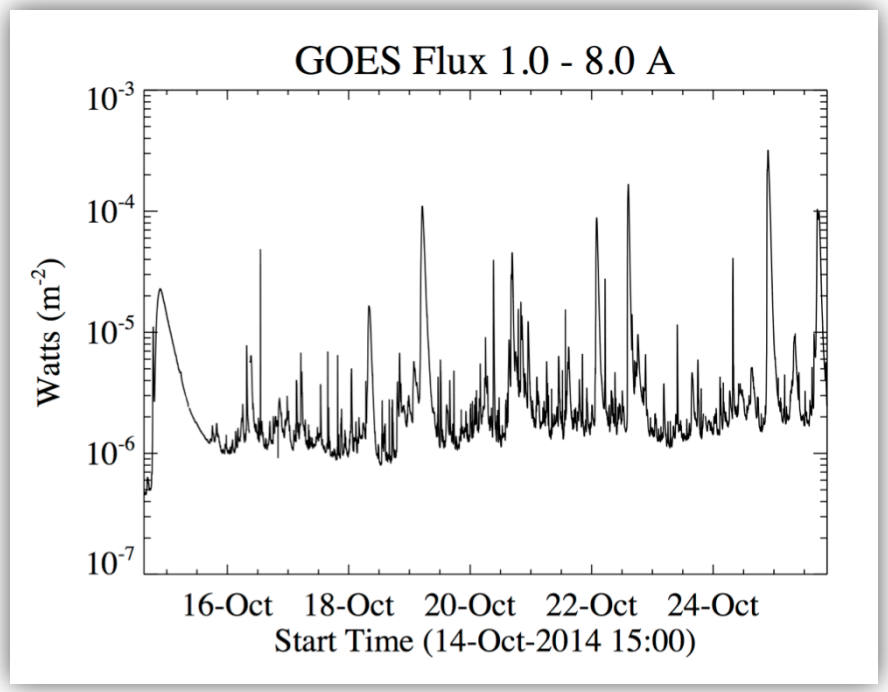
Fig 2: Sheeley & Wang 2007

SADs in the Extended Corona…

SADs in the lower corona are typically observed well after reconnection has occurred.

In the extended corona, we are better able to observe the migrating reconnection sites.

WL coronagraphs allow us to see reconnection develop behind the CME while looking directly at the density.



"Giant Arches" Flare – 2014 Oct 14

Fig 1

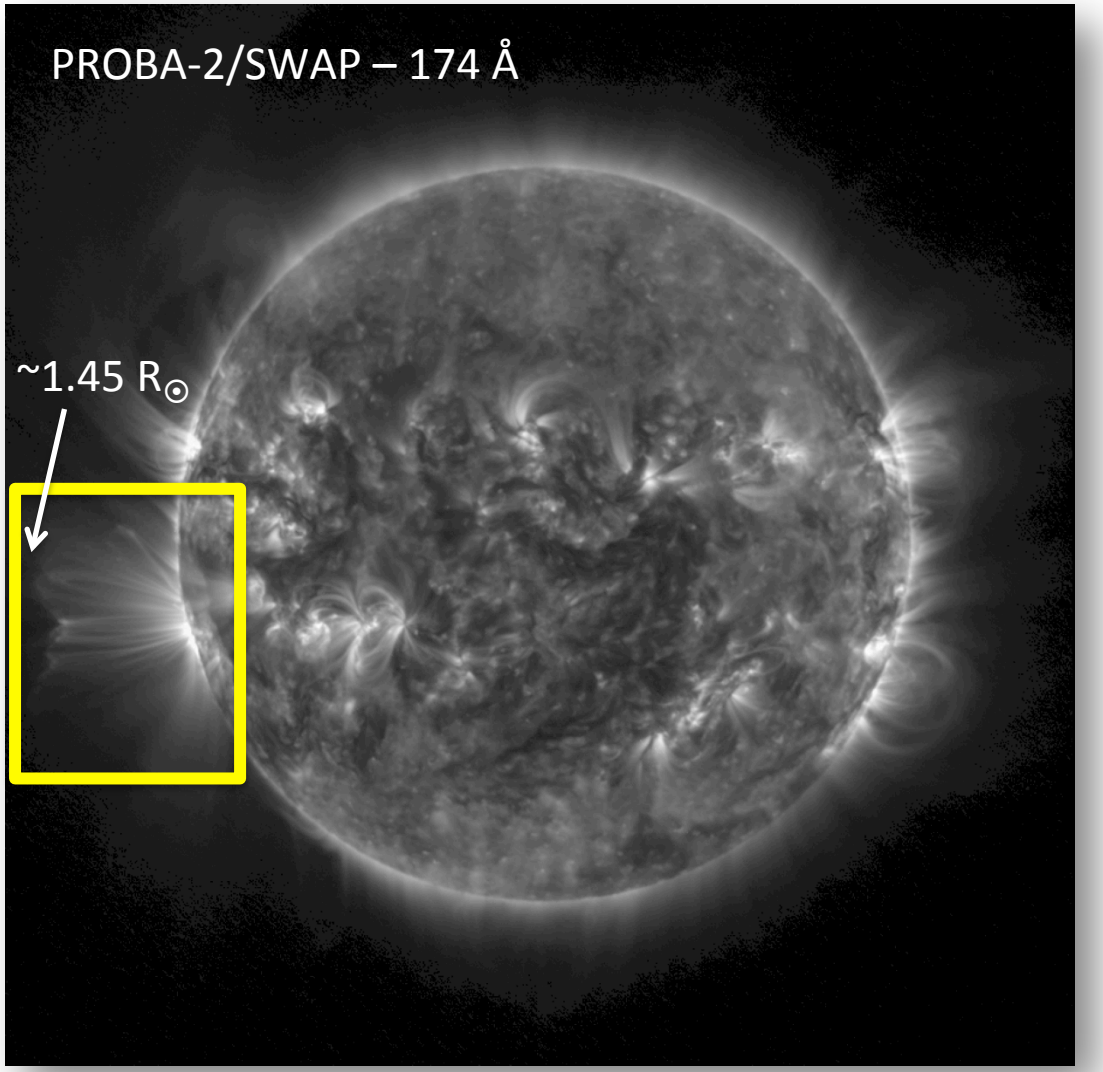


Fig 1: West & Seaton 2015

SADs in the Extended Corona…

LASCO C2
PROBA-2/SWAP
AIA 131 Å

A: Flattened from a year's worth of data

Cleaned (cosmic rays, background stars, planets)

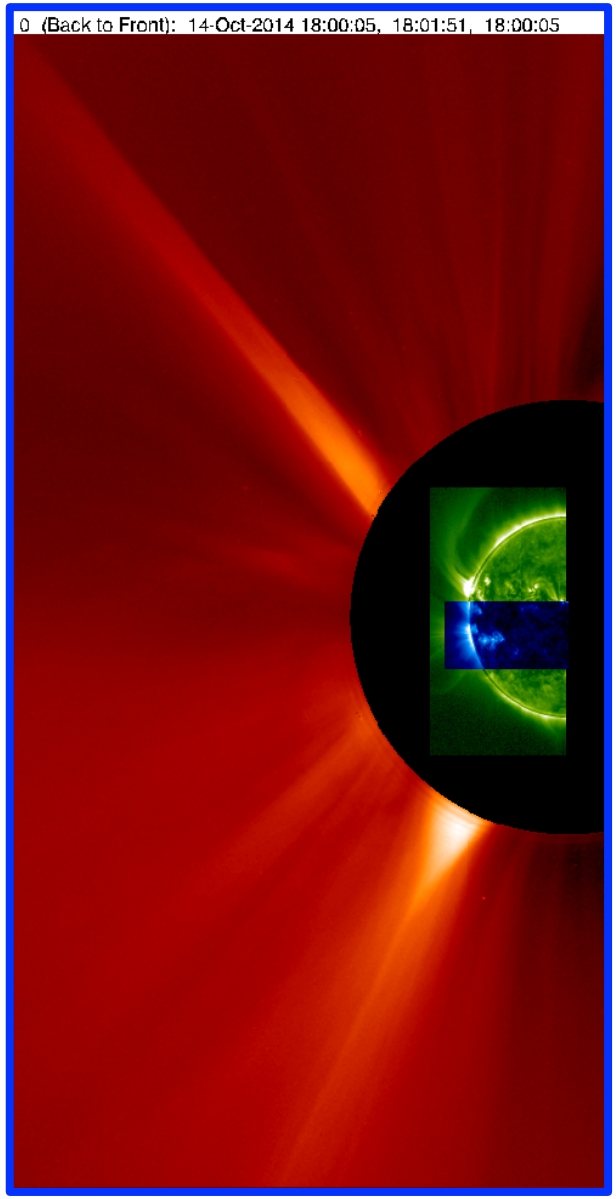
Attenuated disk

B: All that + Run-mean-differenced

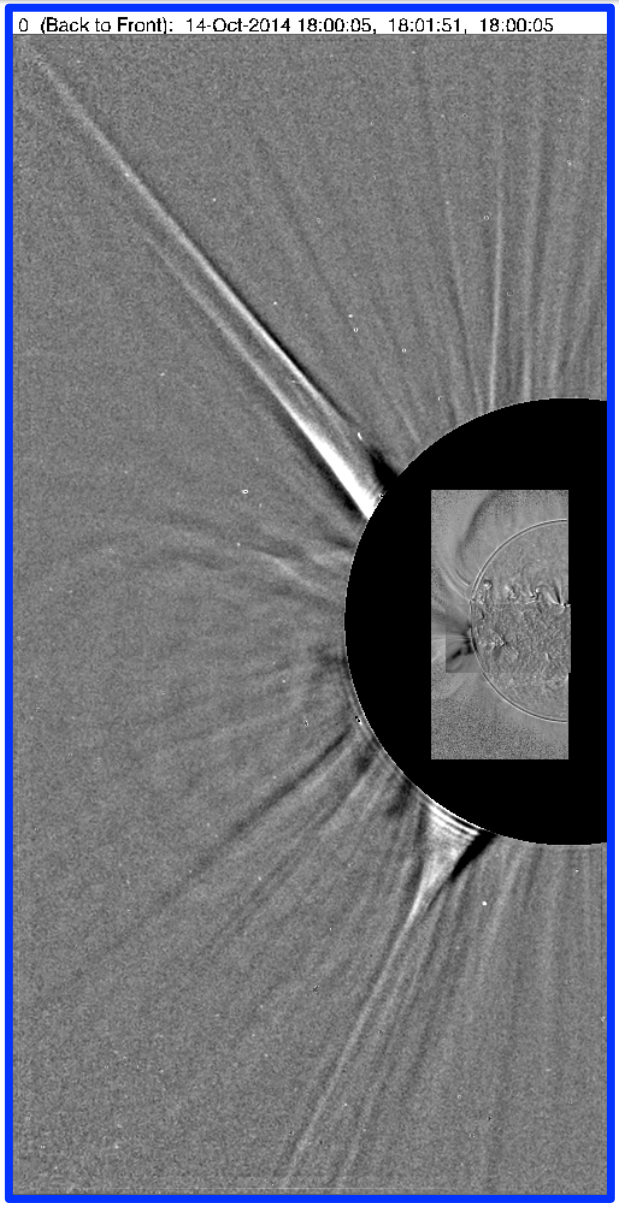
- Both Scaled

Downflows in C3 as well!

A



B



SADs in the Extended Corona…

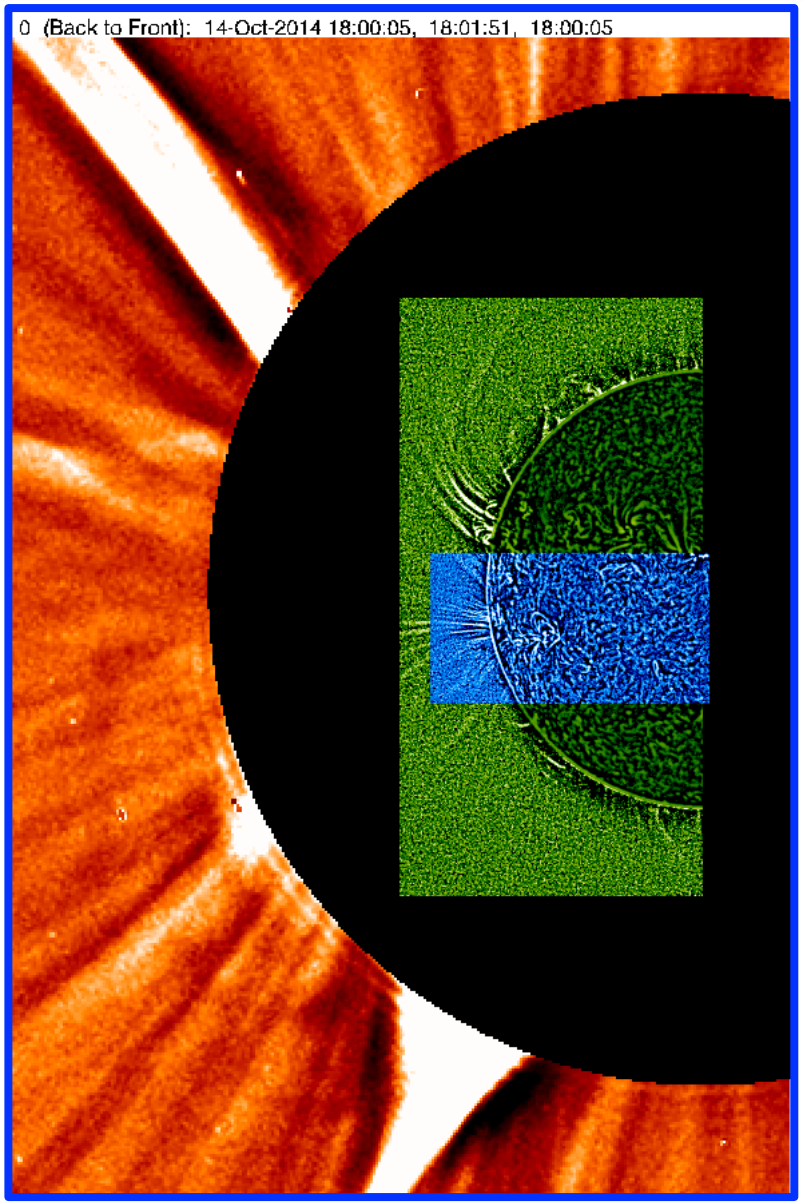
LASCO C2

PROBA-2/SWAP

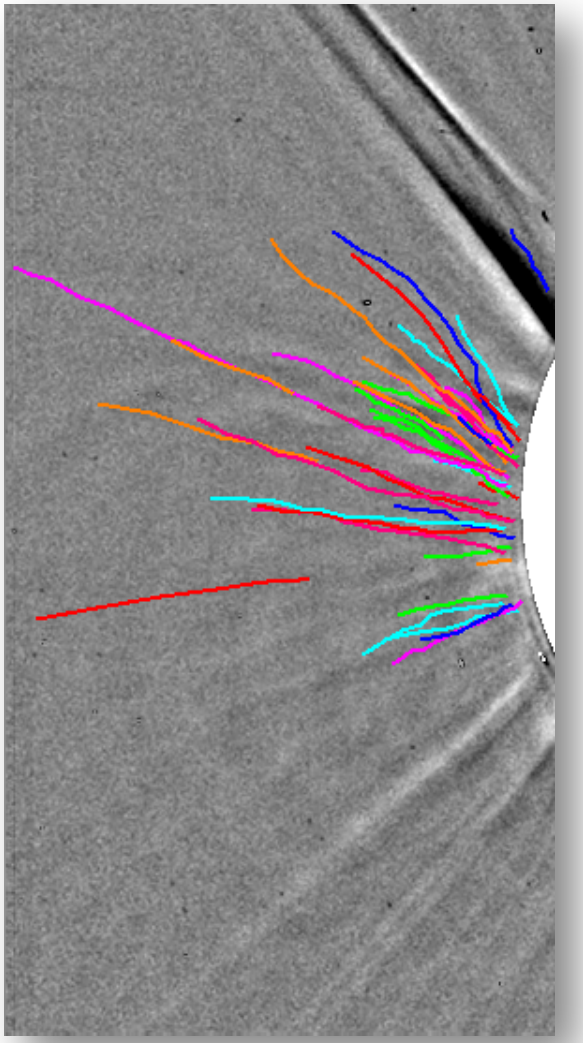
AIA 131 Å

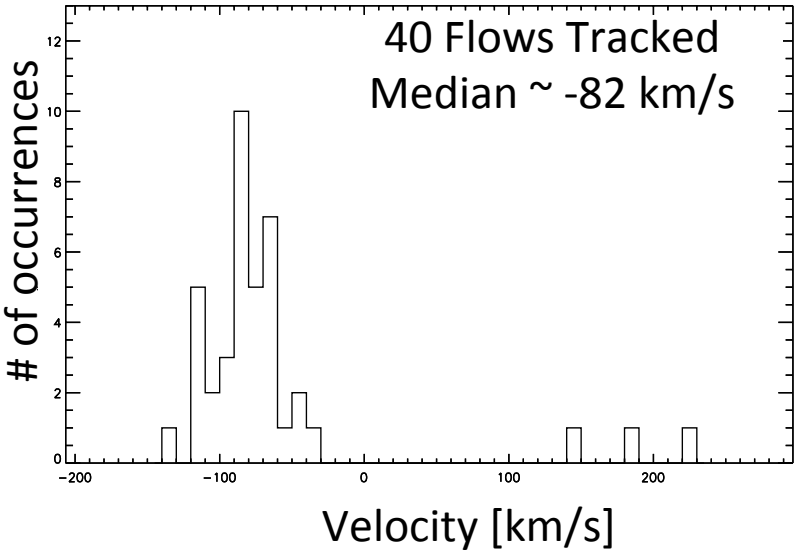
C: Smooth-Differenced
Extracted
Scaled

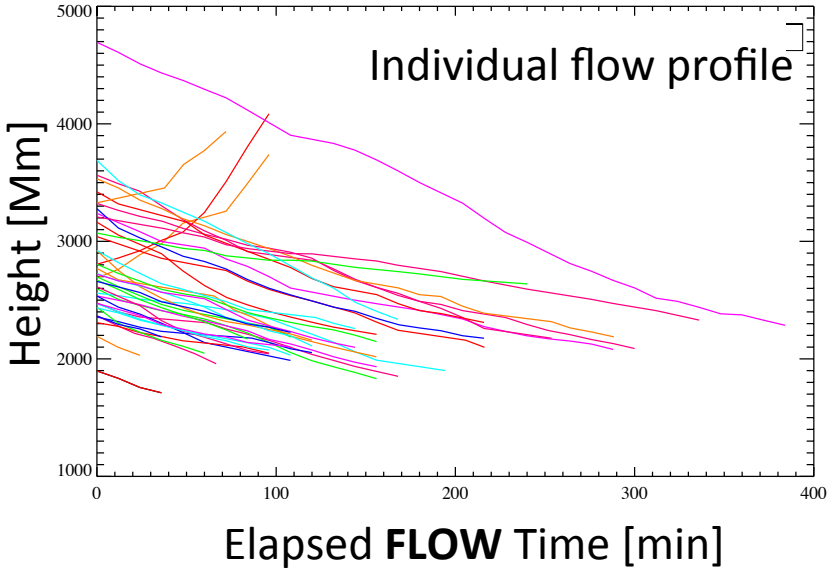
C



SADs in the Extended Corona…







Strong potential analogy with magnetotail substorms

Fig 1

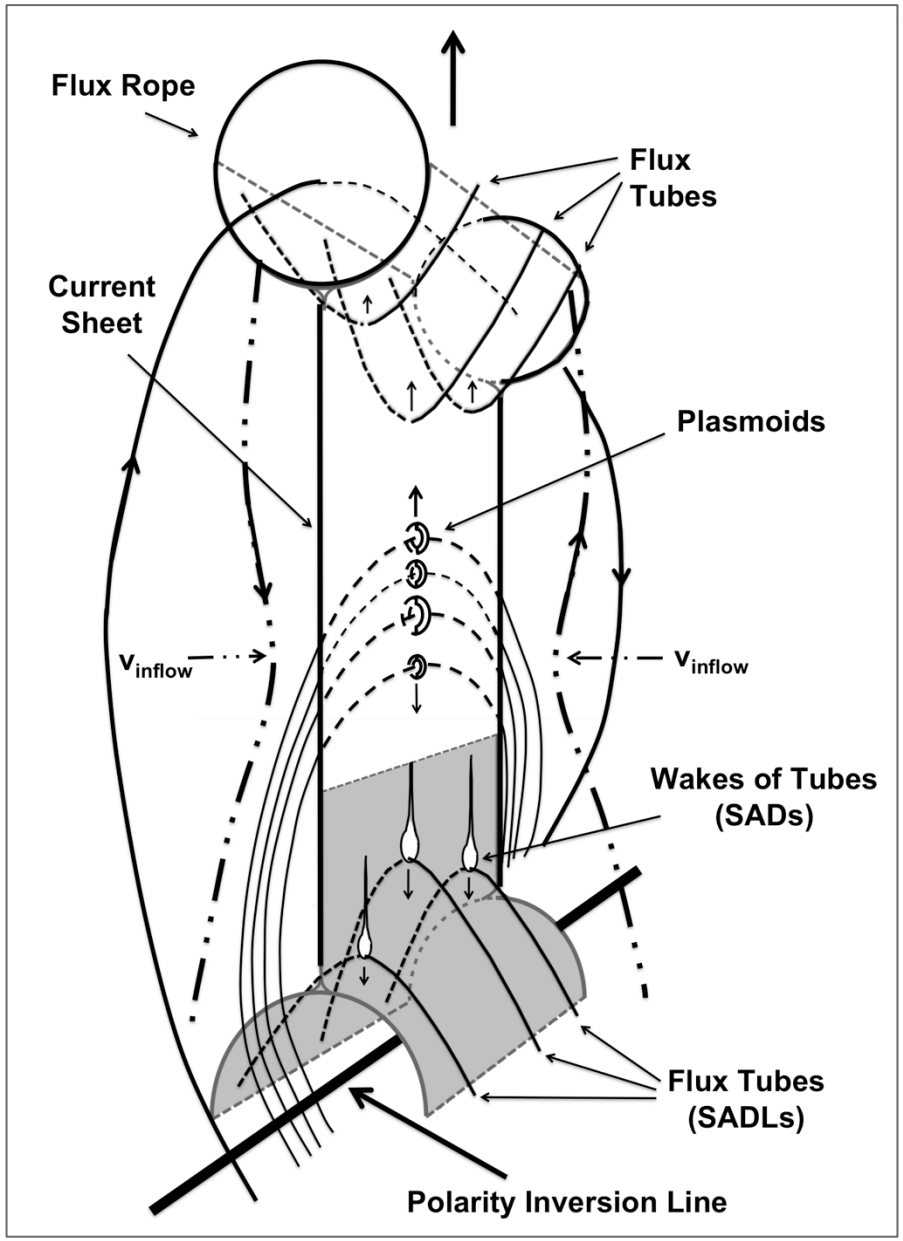


Fig 2

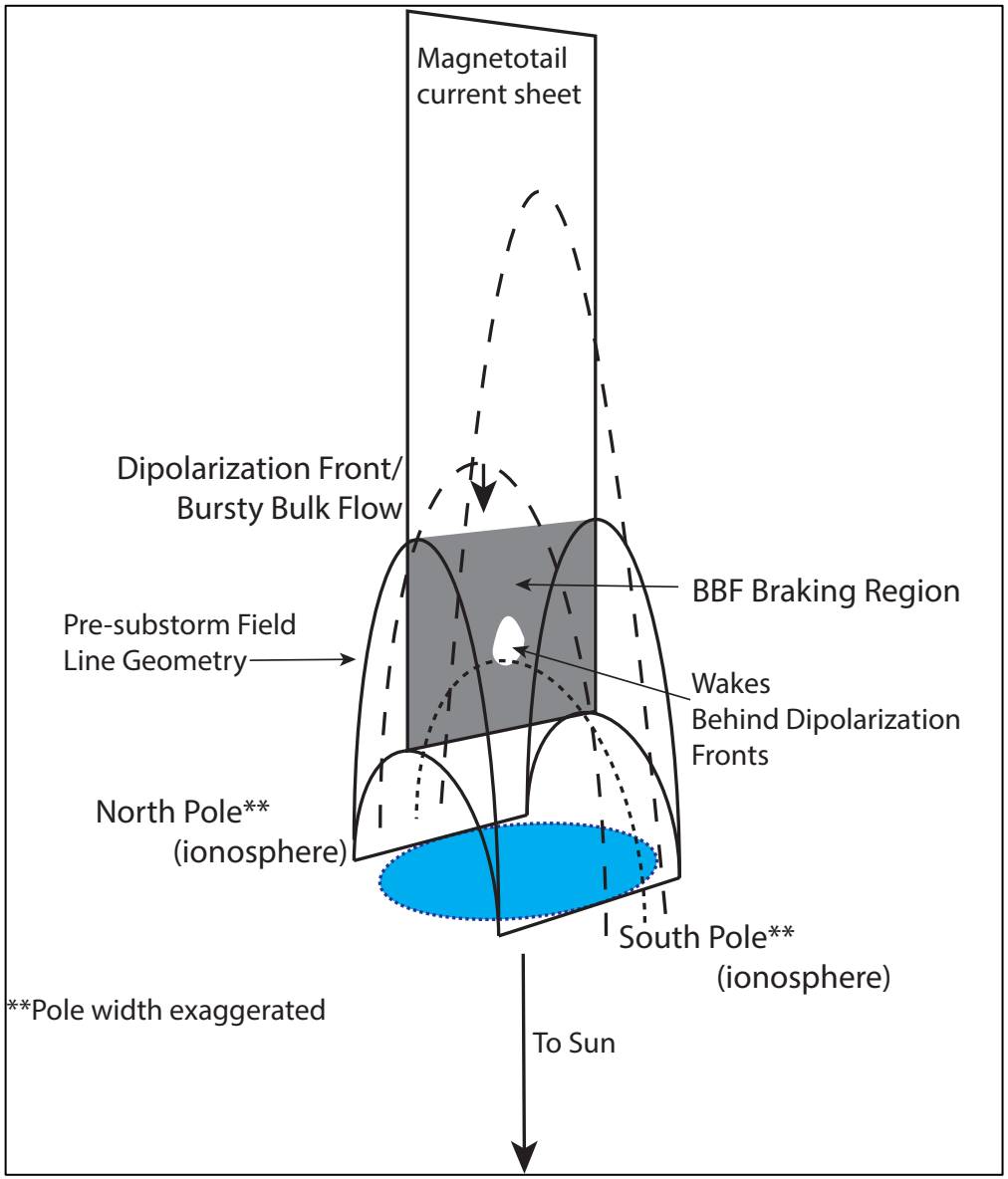
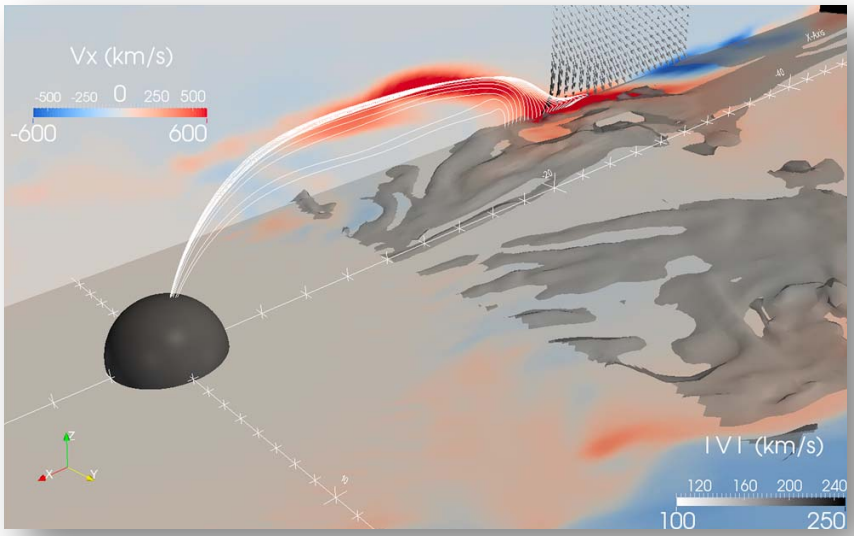
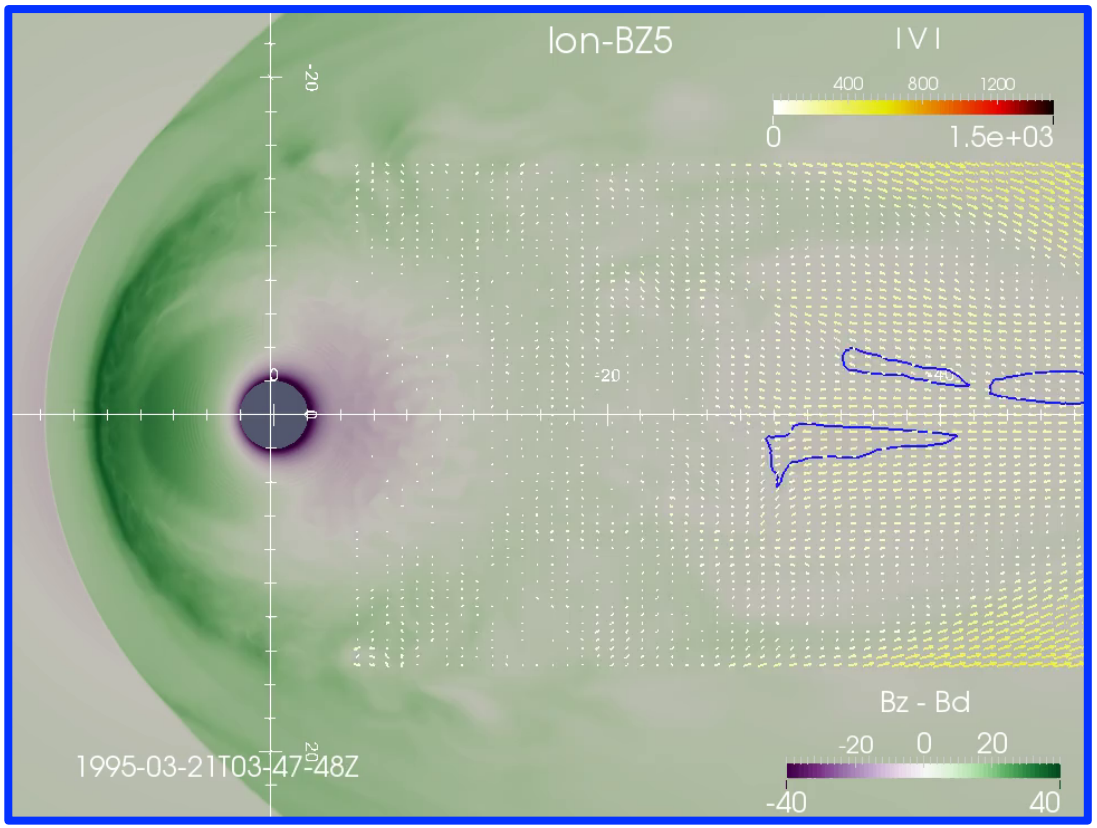


Fig 1: Savage et al. 2012

Fig 2: Courtesy of A. Kobelski, Reeves et al. 2008

Using THEMIS for comparison to *in situ* data





Wiltberger et al. 2015

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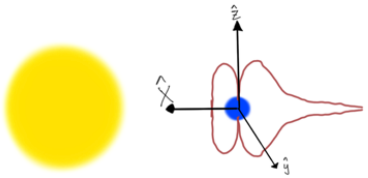
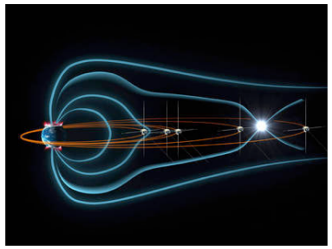
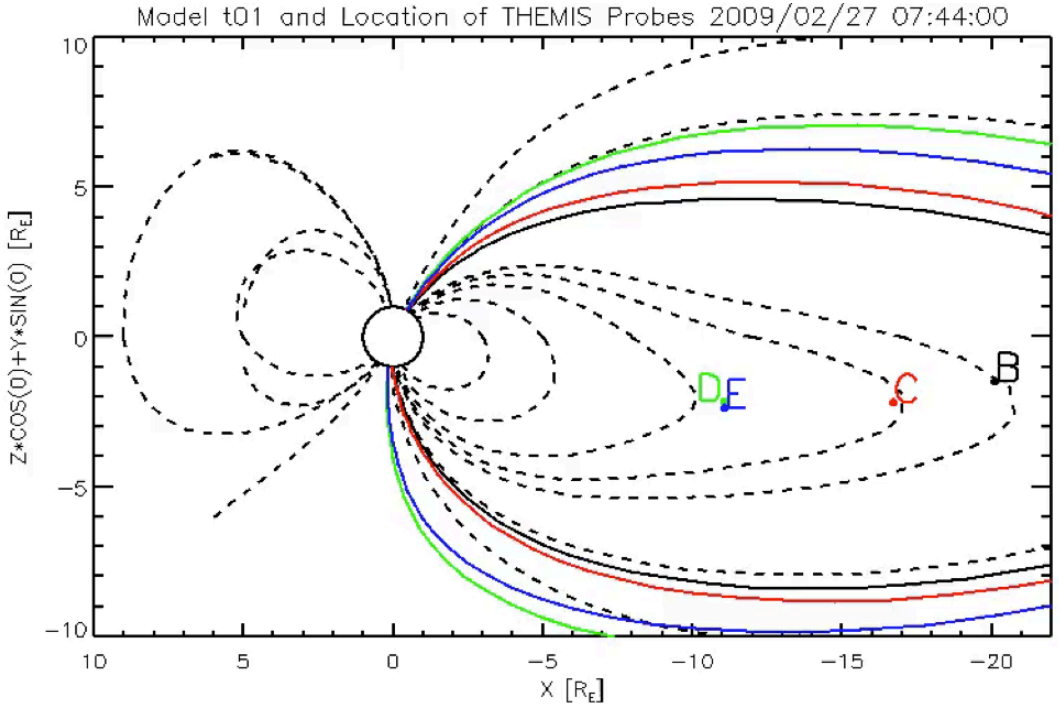
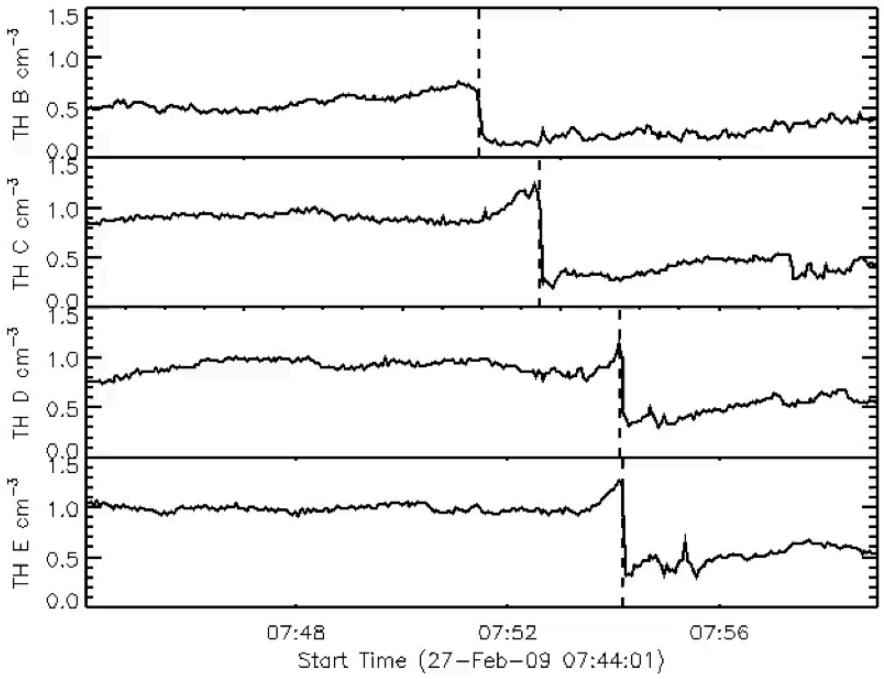




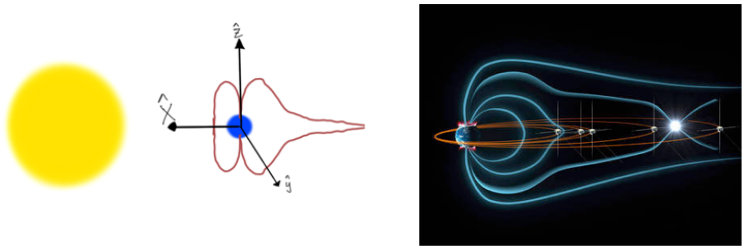


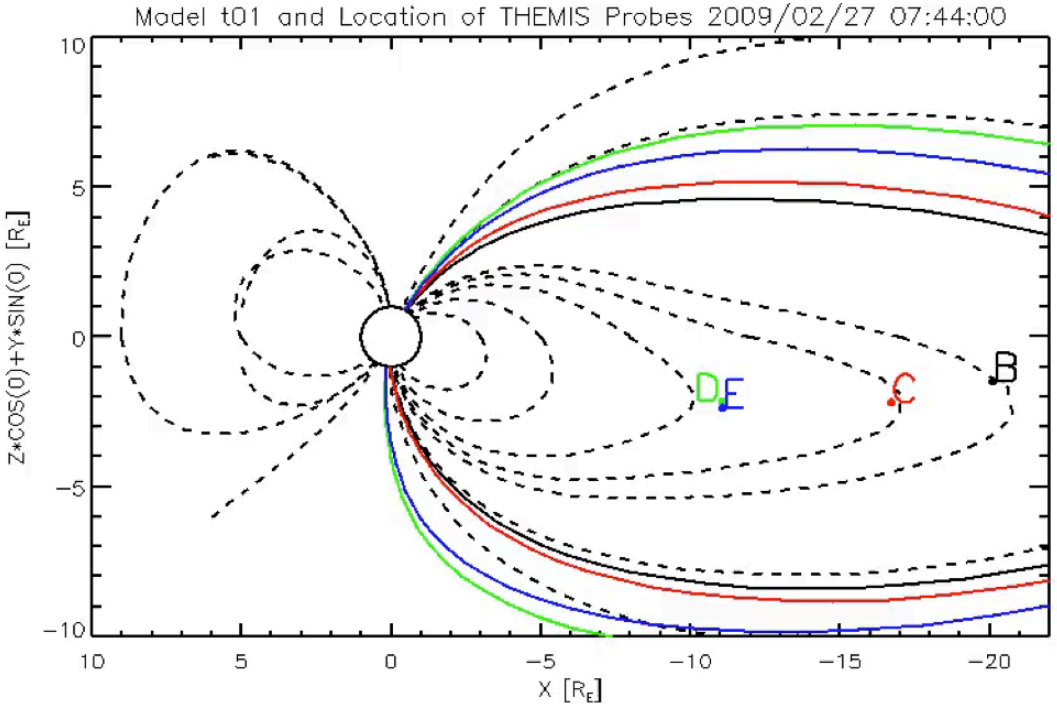


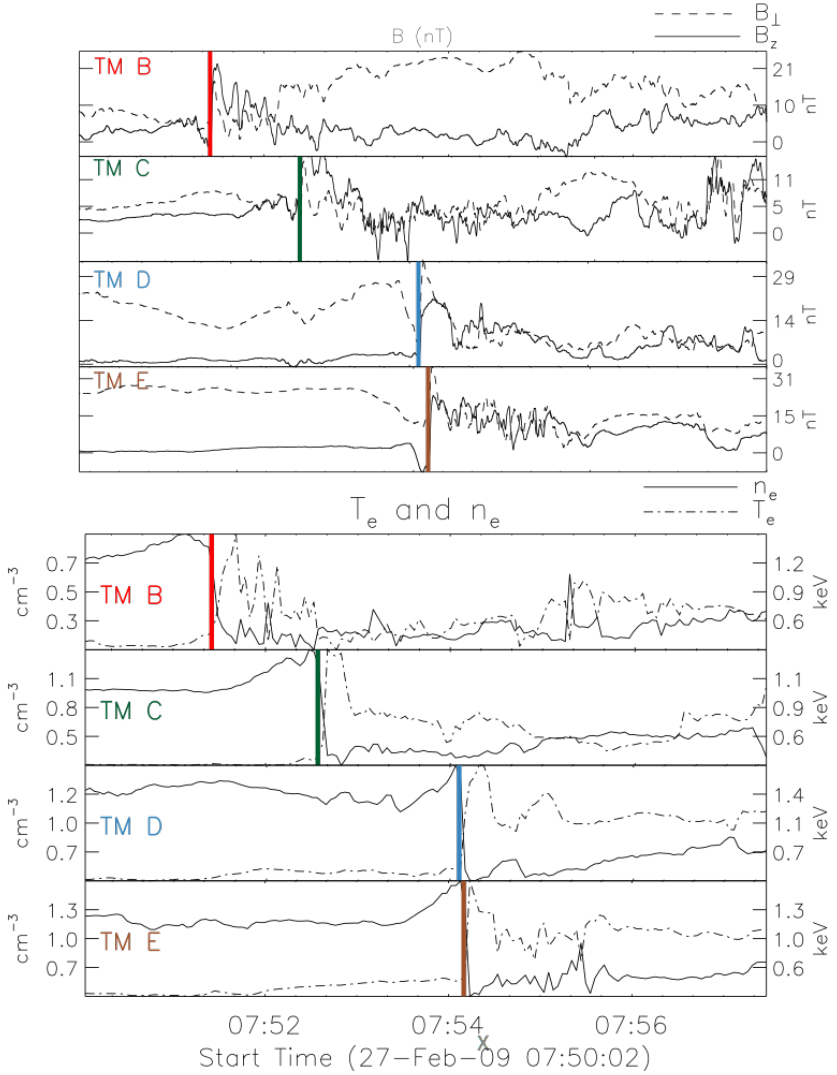
Substantial density drop following the dipolarization event!

Courtesy of Adam Kobelski and David Malaspina based on analysis from Runov et al., 2011

Using THEMIS for comparison to *in situ* data

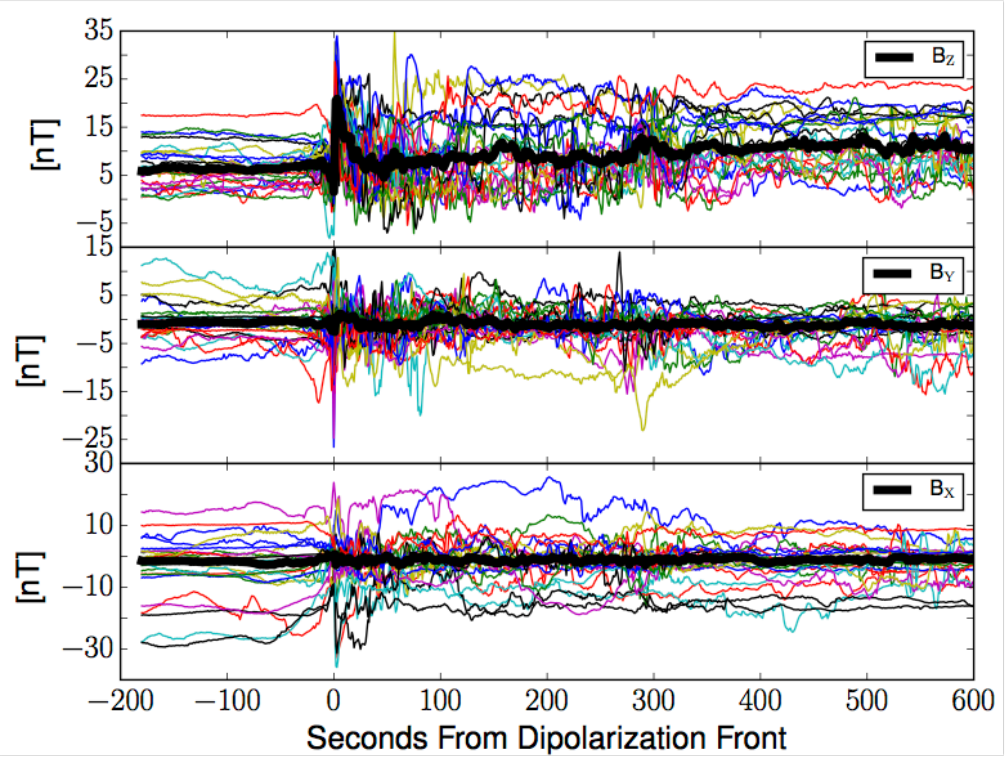


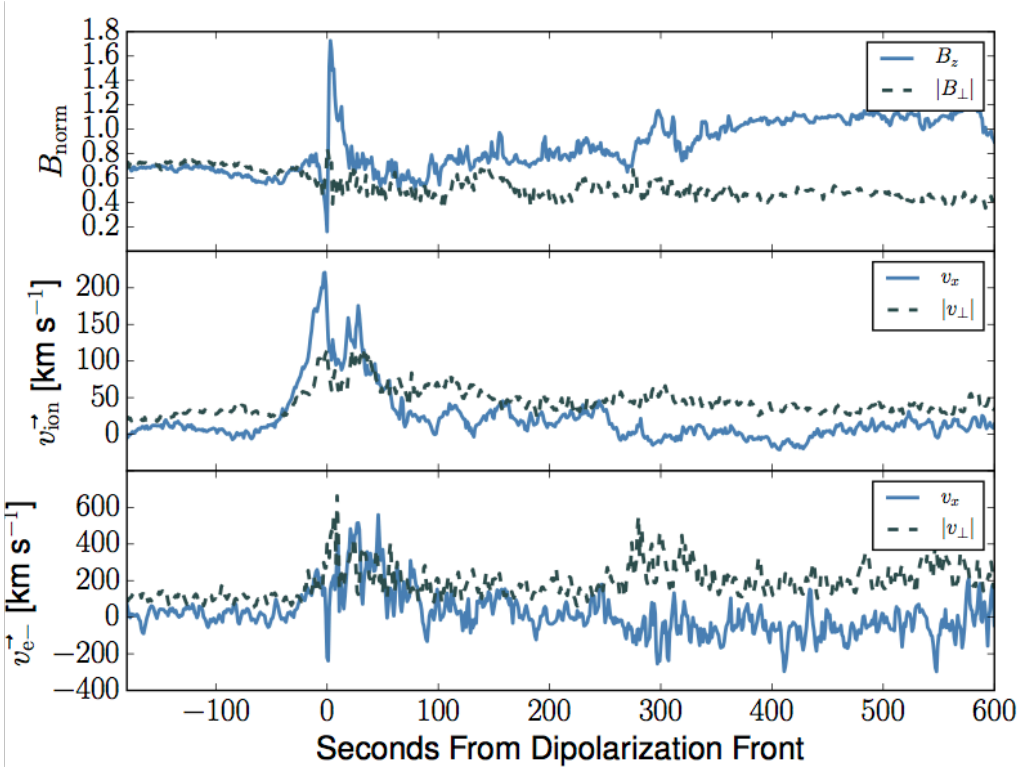




Courtesy of Adam Kobelski and David Malaspina based on analysis from Runov et al., 2011

Using THEMIS for comparison to *in situ* data

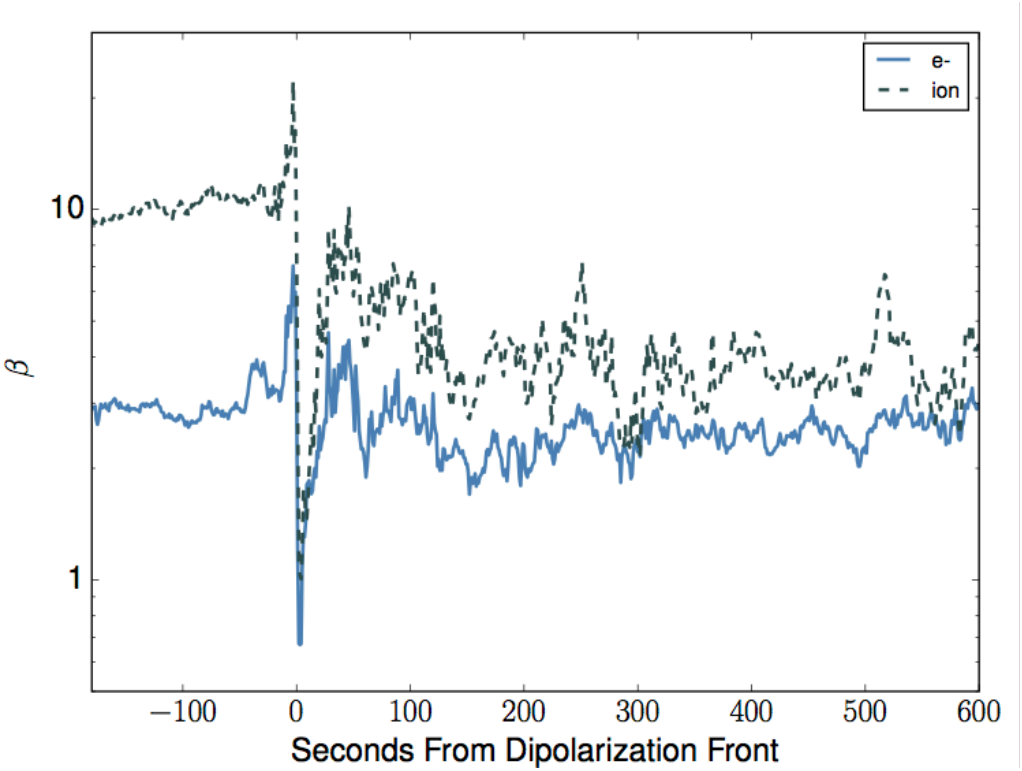


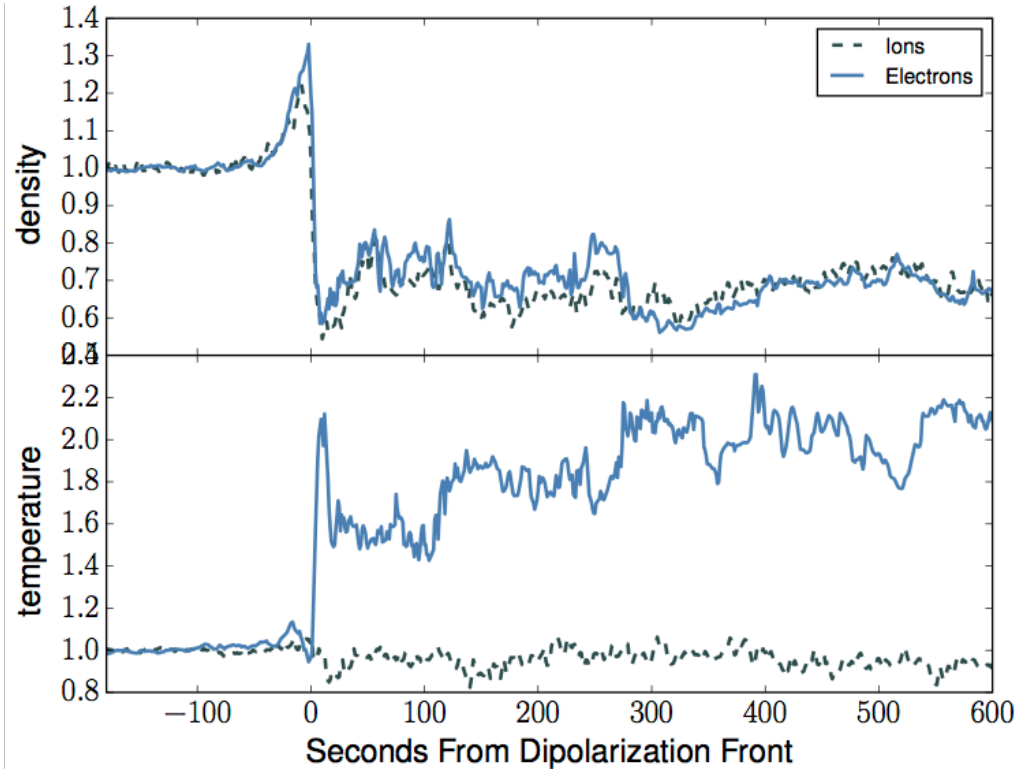


Combination of 6 events observed by up to 5 THEMIS spacecraft
(listed in Runov et al., 2011)

Courtesy of Adam Kobelski and David Malaspina based on analysis from Runov et al., 2011

Using THEMIS for comparison to *in situ* data





Combination of 6 events observed by up to 5 THEMIS spacecraft
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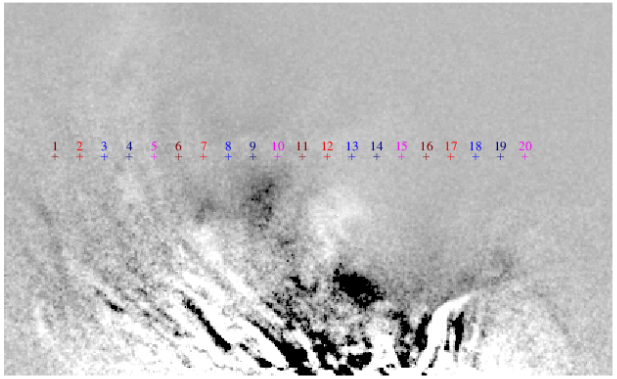
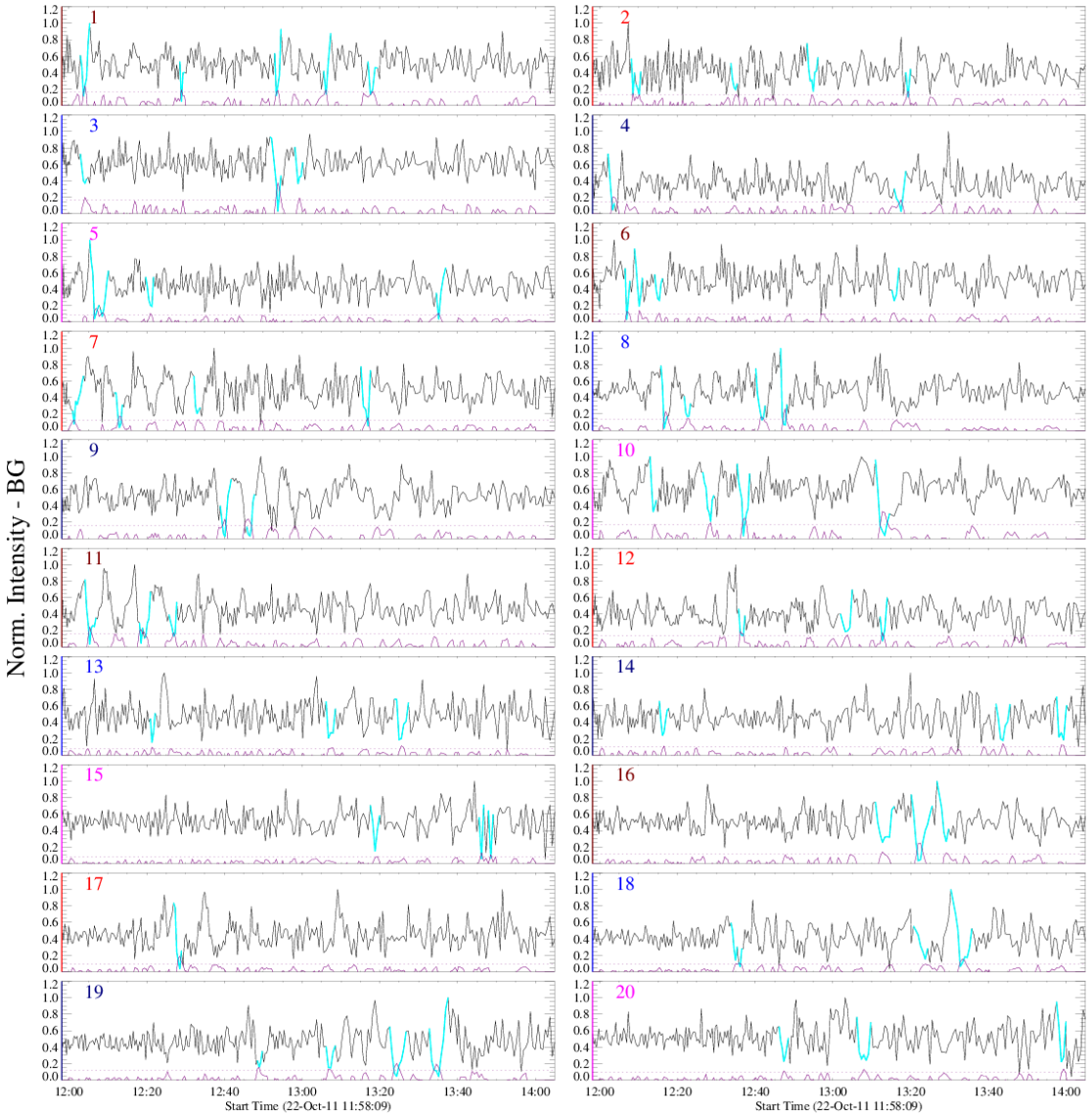
Mimicking *in situ* data sets in the corona





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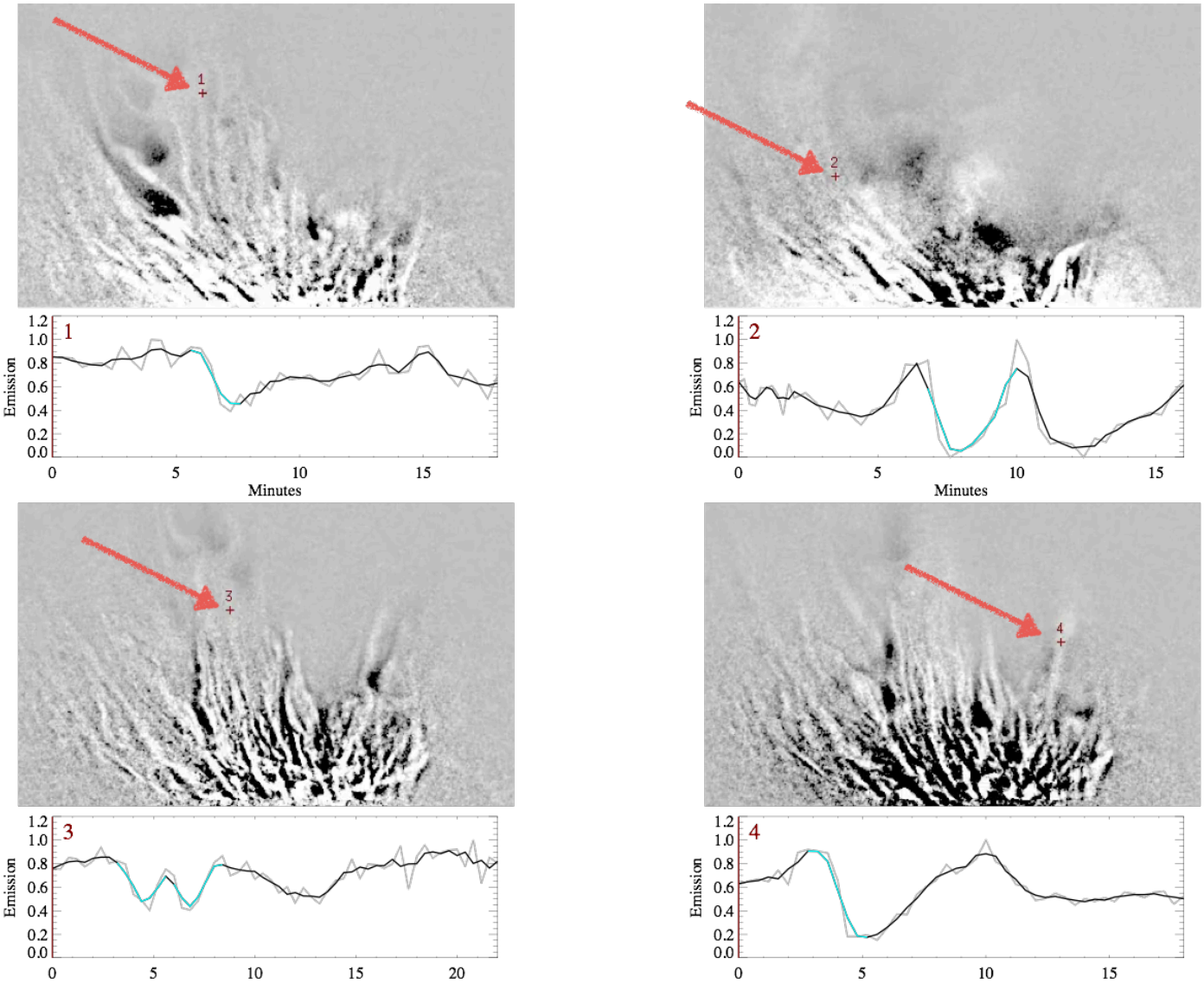
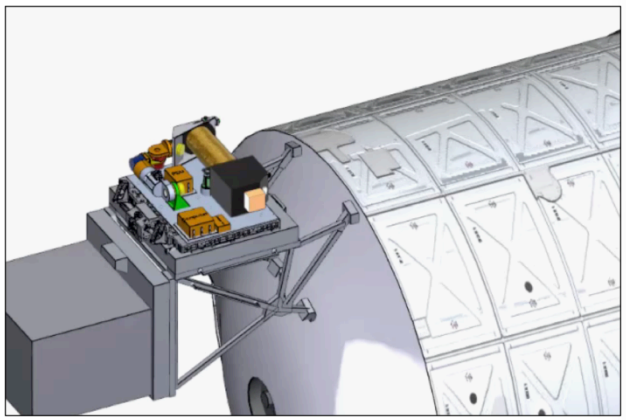
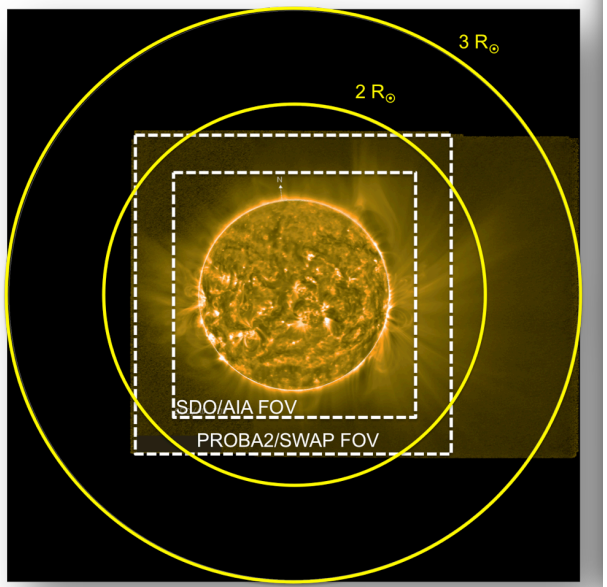
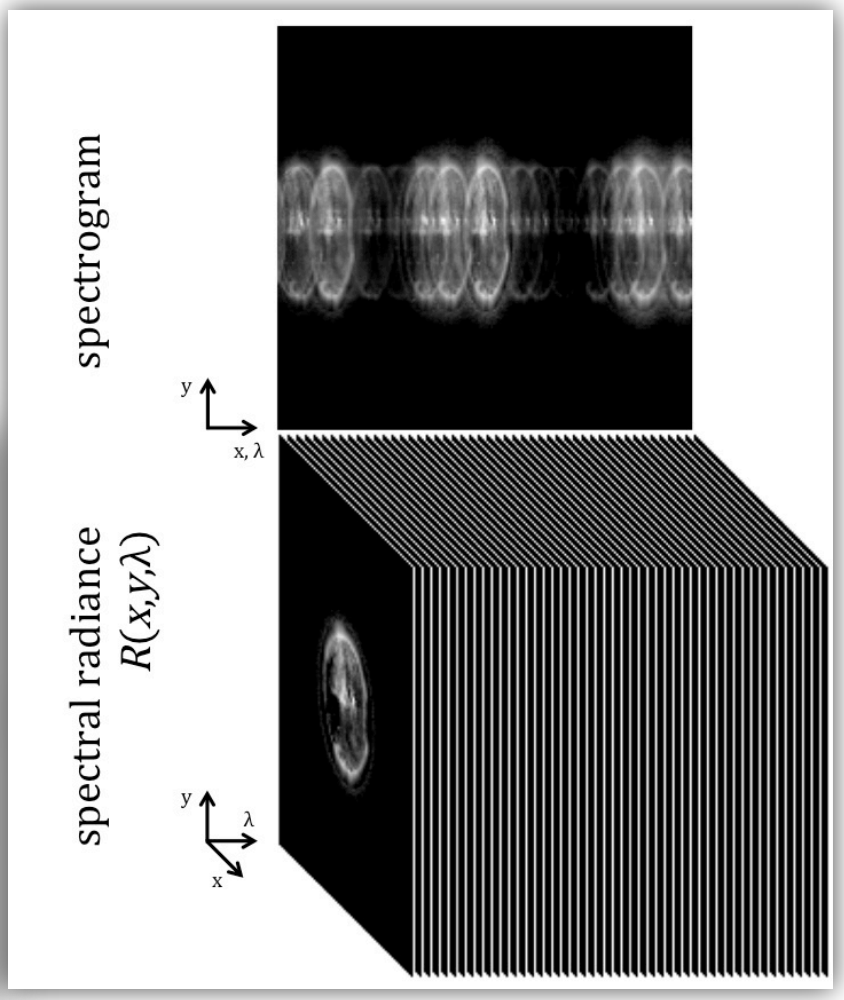


Looking forward

- **Need for instrumentation to fill the gap in observing the transition corona**
  - Important to be in single wavelength
  - Proposed for the International Space Station as a MoO; awarded Technology Development funding…. **[COSIE]**







Take aways

- *In situ* magnetotail data being used to inform remote sensing coronal data (and eventually vice versa…)
- Continuation of shrinking loops can impart energy into the current sheet **long** after the eruption and **high** into the corona.
- COSIE instrument would immensely add to our transitional corona knowledge